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This report covers details of two large-scale field trials of lean concrete base (LCB). By adding additional cement and water to aggregates used for cement treated base (CTB), a plastic mix is produced which can be placed with a slipform paver using only internal vibration for compaction. Between 50 and 100 percent additional cement was required to produce LCB with compressive strength comparable to the in-place strength of CTB. LCB was found to have greater stiffness and a more sealed and abrasion resistant surface than CTB. Some of the increased costs due to additional cement are offset by greater production and the use of less placing and finishing equipment.

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TRANSPORTATION LABORATORY
RESEARCH REPORT

California Trials With Lean Concrete Base (LCB)

75-37

INTERIM REPORT
CA-DOT-TL-5167-3-75-37
OCTOBER 1975

Prepared in Cooperation with the U.S. Department of Transportation, Federal Highway Administration

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TRANSPORTATION LABORATORY

October 1975

FHWA No. D-3-32
TL No. 635167

Mr. R. J. Datel
Chief Engineer

Dear Sir:

I have approved and now submit for your information this interim research project report titled:

CALIFORNIA TRIALS OF LEAN CONCRETE BASE (LCB)

Study made by . . . . Concrete Branch

Under the Supervision of . . . . D. L. Spellman, P.E.

Principal Investigator . . . . J. H. Woodstrom, P.E.

Co-Investigator . . . . B. F. Neal, P.E.

Report Prepared by . . . . B. F. Neal, P.E.

Very truly yours,

GEORGE A. HILL
Chief, Office of Transportation Laboratory

Attachment

BFN:lrb

ACKNOWLEDGEMENTS

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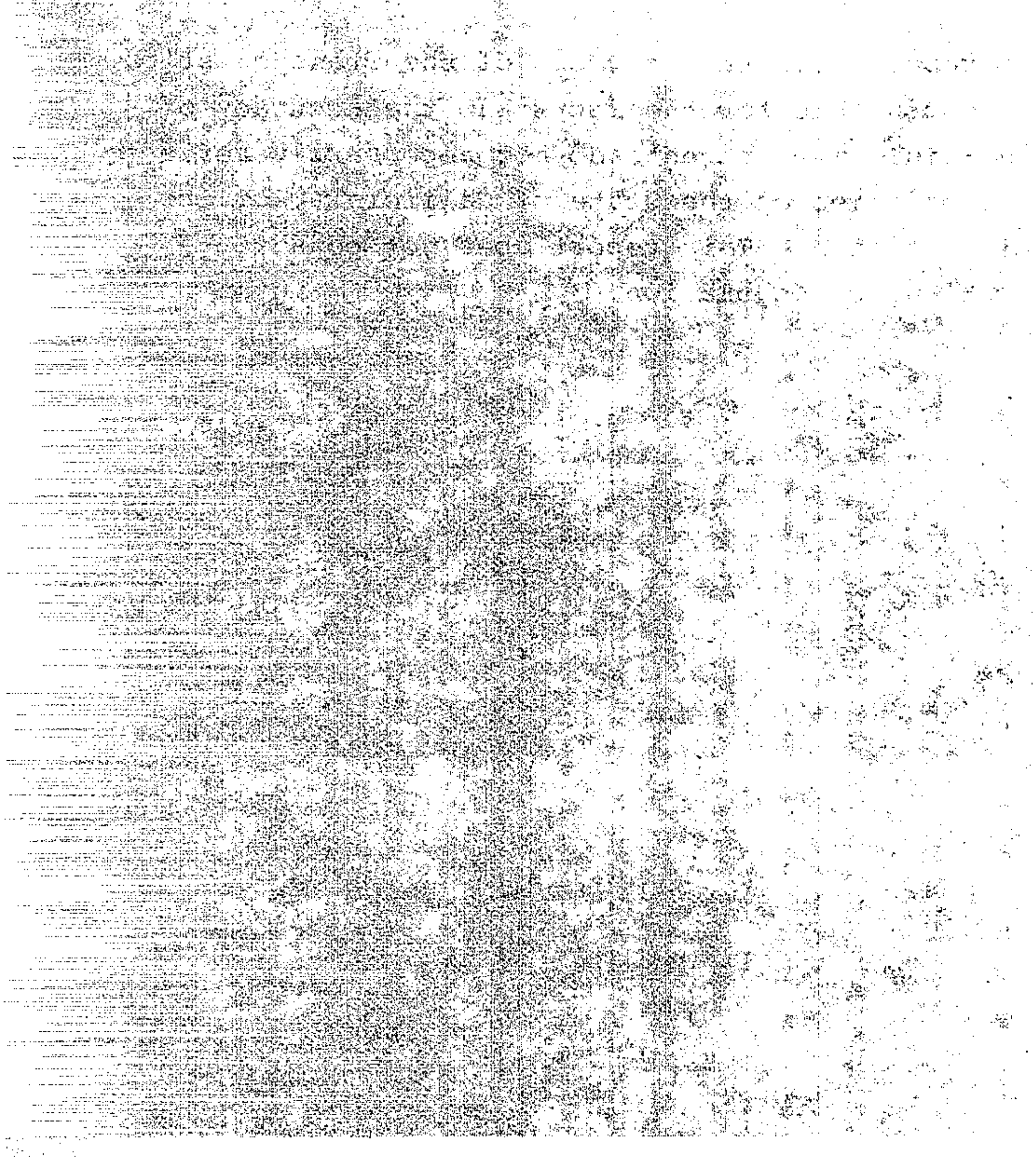

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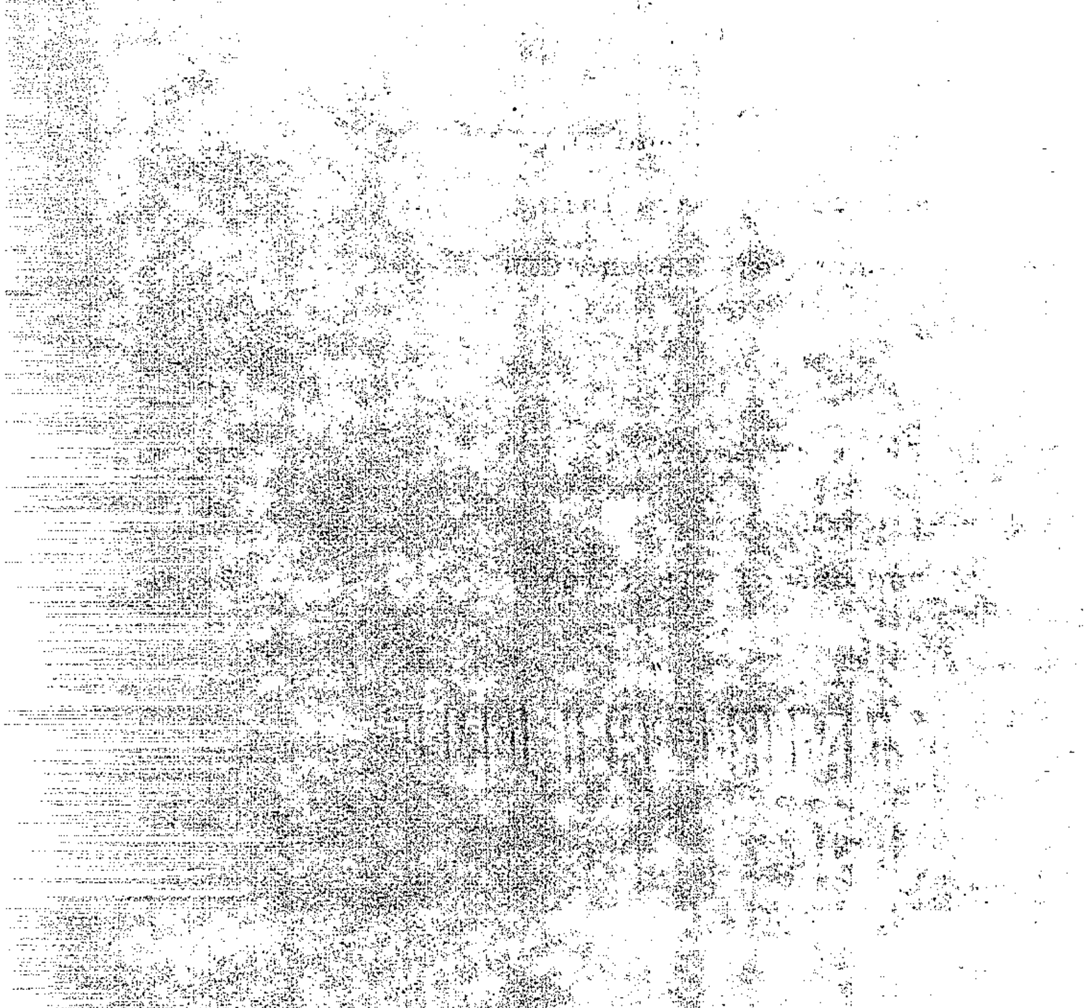


INTRODUCTION

Faulting of joints has long been considered a major problem in unreinforced PCC pavements. In 1970, California reported on an investigation into the cause of faulting (1). The following conclusions were made:

1. Faulting of PCC pavement joints is caused by an accumulation of loose material under the slabs near the joints. This accumulation may occur only under the approach slab, or may be a differential buildup under both slabs with the thicker layer under the approach side.

2. The buildup is caused by violent water action on available loose or erodible materials which are beneath or adjacent to the slabs. The water is moved both backward and transversely by the fast depression of the curled or warped leave slabs under heavy wheel loads, and by the suction caused by release of the load on the approach slab, eroding and transporting any loose material.

3. The major sources of the buildup material are the untreated shoulder material and the surface layer of the underlying base. Minor amounts may come from abrasion of the concrete joint interface and from material on the pavement surface moving through the joints.

In early 1972, another report was made which offered possible solutions to the faulting problem (2). One of these was to provide a more erosion resistance base. Present practice of placing cement treated base (CTB) involves compacting, then trimming the surface to proper grade. Trimming is usually performed an hour or more after placement and the surface material, once loosened, is never fully rebonded. As a result, the CTB surface is not as erosion resistant as needed.

A proposal was made to add additional cement and water to CTB aggregate to make "lean concrete" and place it with a slipform paver. By placing the material like concrete pavement, with internal vibration, no further compaction and no trimming would be needed. A laboratory investigation of lean concrete base (LCB) was conducted comparing properties with those of CTB made with the same aggregates. The LCB variables included (1) six aggregate sources; (2) three cement contents; (3) three moisture contents; and (4) three gradings. A summary of the results are included in the report. Briefly, it was found that:

1. Compressive and flexural strengths <u>increased</u> with higher cement contents, lower moisture contents, and coarser gradings.

2. Abrasion losses <u>decreased</u> with higher cement contents, lower moisture contents, and coarser gradings.

3. Workability <u>increased</u> with higher cement contents, higher moisture contents and finer gradings.

4. To obtain a 7-day compressive strength of 750 psi, more than twice as much cement would be needed for LCB than for CTB.

The 750 psi compressive strength for CTB is a design criterion based on specimens fabricated at 100% relative compaction. Field relative densities, however, are required to be at only 95 percent. For LCB to have a compressive strength equivalent to that of in-place CTB, 500 psi (or perhaps even less) would be more realistic. This would require considerable less cement and help to make LCB more competitive in cost while maintaining comparable strength.

The encouraging results of the laboratory study led to discussions with contractors in an effort to promote the trial of LCB on a fairly large scale basis. In 1972, the first test of LCB under field conditions (in California) was made. Results of this trial are reported here under "Monterey Project". More than two years went by before another contractor proposed using LCB. The latest trial is reported here under "Compton Project". In the intervening years, the use of LCB was written into the specifications of several projects not yet to the paving stage. Most of these projects have asphalt concrete surfacing. On one, the Contractor has the option of placing either CTB or LCB.

CONCLUSIONS

Based on laboratory tests and the two field trials of LCB, the following conclusions are considered warranted:

1. By adding additional cement and water to aggregates suitable for CTB, a plastic mix is produced which can be placed with a slipform paver using only internal vibration for compaction.

2. Some additional cement is required to produce LCB with compressive strength comparable to the in-place strength of CTB. The needed amount must be determined by laboratory tests using aggregates selected for the project.

3. Production rates of LCB are greater than those of CTB.

4. Less equipment is needed to mix and place LCB.

5. LCB is more impermeable.

6. An LCB surface is more abrasion resistant than that of CTB.

7. LCB has greater stiffness. Benkelman beam deflections of LCB were about half those of CTB.

8. Most of the increased costs of LCB (mainly the additional cement required) are offset by higher production rates, less equipment need, and less overrun in concrete pavement quantities due to better control of final grade and cross-section.

9. Laboratory tests indicate that the use of coarser graded aggregates with less fines would result in the need for less cement to produce strengths comparable to those of in-place CTB.

RECOMMENDATIONS

The use of lean concrete base should be greatly extended. This can be accomplished under the following conditions:

1. On current contracts, allow substitution to be made where the specific job situation allows. This should be encouraged even though costs may result in a small net increase to the State. The benefits expected in reducing the joint faulting problem make additional costs worthwhile. Consider reduction in thickness of the stabilized base layer by 0.05-ft. if LCB is to be used.

2. Develop specifications allowing LCB as an alternate to CTB utilizing the above mentioned thickness reduction.

3. Specify LCB on all new projects where it is deemed appropriate.

Further study on the costs and effectiveness of LCB should be conducted.

MONTEREY PROJECT

(March, 1972)

The first field trial of LCB in California was conducted on State Highway 1 on the coast near Monterey. The proposal to try LCB was made by the prime contractor, Milburn Construction Company and McAdoo White Company, Inc., JV, and the paving subcontractor, Owl Slipform Concrete Company. Discussions between the Contractor, State Construction personnel and Laboratory researchers were held to work out details of the project. Agreement was reached on a contract change order to provide additional payment where additional costs were incurred. Following is a discussion of some of the items covered in the change order:

1. On one planned paving stage, consisting of 10,875 lineal feet of 36 foot wide pavement, LCB would be used in lieu of CTB.

2. Planned base thickness (0.35-ft.) and width (38-ft.) would be maintained.

3. Aggregate for LCB would be the same as used for CTB on other portions of the project.

4. Two longitudinal weakened plane joints in the LCB, offset 1-ft. from the planned interior pavement lane lines, would be constructed with plastic inserts. The offset was to prevent coincidental cracks in the base and pavement surface course. Joint material was included as Extra Work.

5. No transverse weakened plane joints would be constructed in the LCB.

6. A pigmented liquid concrete curing compound would be used in lieu of the liquid asphalt curing seal required for CTB. The pigmented compound is considered to be superior to asphalt as a curing seal. (Obtaining a hard, durable surface was one of the prime considerations in the proposed use of LCB.)

Increased costs of curing were included as Extra Work.

7. The increase in amount of cement required for LCB was to be paid for at an agreed price.

Samples of the aggregate proposed for use in CTB and LCB were obtained for laboratory tests. Grading of the material was as follows:

Standard Sieve	Percent Passing
3/4-inch	100
3/8-inch	79
No. 4	59
No. 30	27
No. 200	12

Sand Equivalent was 35 $\pm$

Laboratory tests indicated only 3.5 percent cement and 8 percent moisture would be needed to produce CTB meeting the design criterion of 750 psi at 7 days.

Tests of LCB mixes with 7 and 9 percent cement gave average strengths of 365 psi and 575 psi respectively, at 7 days. Considering the relationship between laboratory and field conditions a cement content of 8.5 percent for the LCB was selected. Approximately 13 percent moisture by dry weight of the aggregate was required to provide laboratory workability.

On the day before field placement started, a few trial batches of LCB were made. Samples were obtained for testing and the mixed material was spread to make pads for future aggregate stockpiles. The trial batches all appeared to be satisfactory.

The following morning, production batches were mixed in a 7.5 cubic yard central mix plant, then hauled in dump trucks and deposited in front of the paver. A front end loader was used to provide uniform distribution. For the first few hundred feet of placement, the paver was unable to finish the material properly, leaving numerous surface tears (see Figure 1). To correct this problem, a small amount of air-entrainment and more water was added. These adjustments resulted in a smooth sealed surface with sharp vertical edges (see Figure 2) and no further placing problems were encountered. The moisture content had to be maintained at about 17 percent by weight of the aggregate to produce satisfactory results. Slump was 3 to 4 inches.

Five sets of samples were obtained during the three days of placing LCB. Tests included slump, unit weight, and air content on the fresh mix, and titration tests to check on cement content. Results are shown in Table 1. Compressive strength tests of the hardened mix are shown in Table 2.

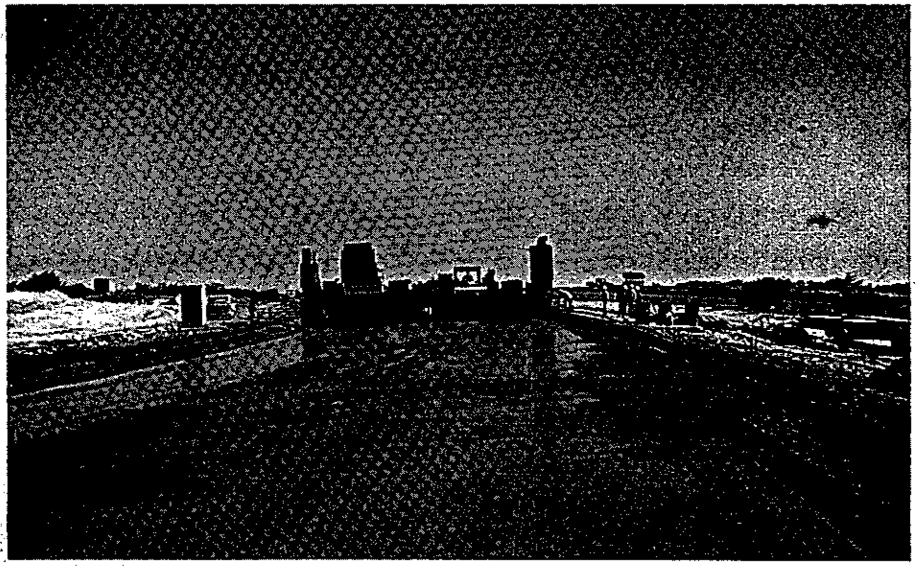


Figure 1
Surface Tears on LCB

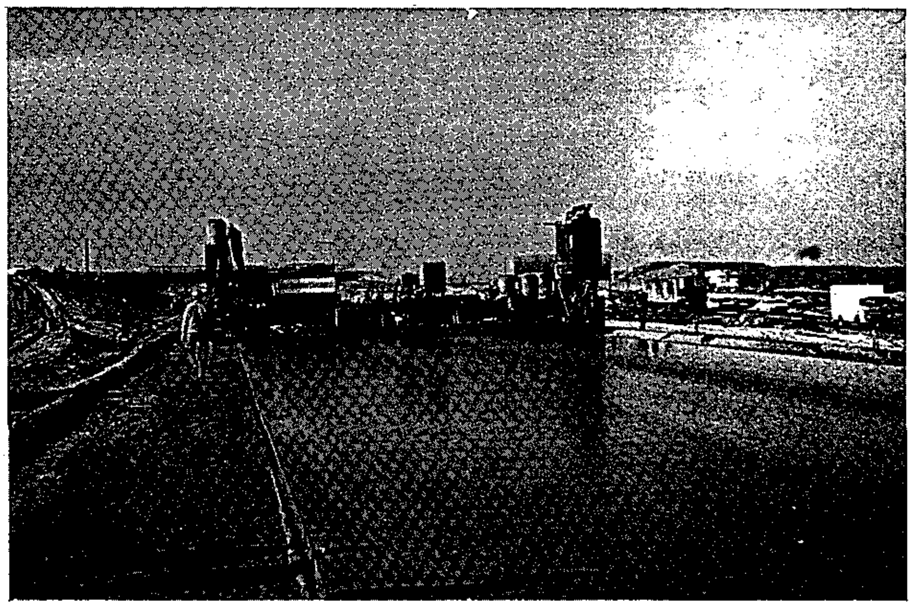


Figure 2
Smooth Sealed Surface

Table 1

Tests on Fresh LCB - Monterey

Test	Slump, Inches	Air Percent	Unit Wt. Lbs./CF	Cement Content* Sks/CY
1	2.75	2.0	143.1	2.78 (Design, 2.89 sk.)
2	4.0	2.1	141.8	2.69
3	3.0	2.3	143.3	2.75
4	3.5	2.0	143.7	2.80
5	---	---	-----	----

*By titration test

Table 2

Tests on Hardened LCB - Monterey

		Compressive Strength							
		4-in. dia. x 4-in. High Briquettes (1)			6x12-in. Cylinders (2)			4" Cores (3)	
Age	Days	7	28	91	7	28	91	14	180
	1	580	1050	1360	460	815	1320		
Set	2	415	820	1125	305	545	1025		
No.	3	405	820	1240	305	645	1070		
	4	485	900	1315	325	635	1060		
	5	410	830	1275	255	545	970		
	Avg.	460	885	1265	330	635	1090	505	1065

(1) Each value an average of 3 specimens
(2) " " " " " 2 "
(3) " " " " " 11 "

Note: Fresh mix specimens were compacted by external vibration.

Paving operations were prohibited on the LCB for a period of 72 hours after placement. At the end of this period the Contractor started concrete paving operations. Very few cracks could be found in the base, probably due to the cool and damp weather conditions. While the LCB was not used as a haul road by loaded trucks, some maneuvering on the base in front of the paver was permitted. A close check was kept throughout the paving, but no cracks were found to have developed in the LCB from this early use. There had been some apprehension in this regard since the LCB was considered to be more brittle than CTB. To try to determine relative stiffness, Dynaflect measurements were made on the LCB at ages up to 5 days, then compared to measurements obtained later on CTB at the same ages. Although there was some variability in the results, it appeared there was no significant difference in the deflections.

On the whole, the test project was considered successful. The high cement content needed for LCB was probably due to the extremely fine grading of the material and the additional water used. The Contractor was satisfied with production rates and considered the early problems as minor. He also stated that his overrun on paving concrete was less than usual. This was because he was able to place LCB to a closer grade tolerance than he could for CTB where allowance has to be made for compaction. Because of penalties for pavement thickness deficiencies, Contractors tend to place and/or trim CTB slightly below the required grade, causing an overrun in pavement concrete quantities.

In 1975, cores were obtained and tested to compare uniformity of the two products. They were taken from both LCB and adjacent CTB which was placed a year later. Six cores of each material were broken in compression. Average strength of the LCB at age 3.3 years was 1575 psi, ranging from 1525 to 1630, (105 psi). Average strength of the CTB at 2.3 years was 1510 psi, ranging from 1310 to 1830, (520 psi). While average strengths of the two materials are about the same, strengths of CTB are much more variable.

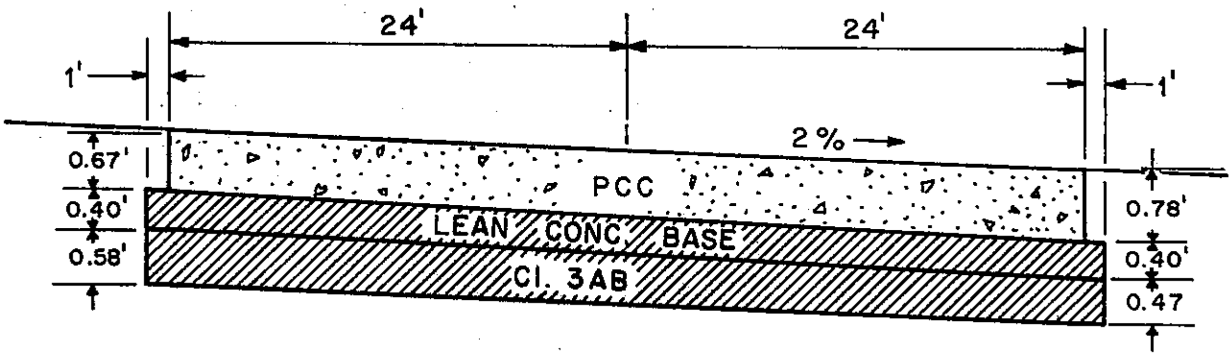
It should be noted that CTB cores (asphalt curing seal on top of CTB) were well bonded to the pavement concrete. The LCB cores were loose when removed, with bond (if any) broken by the action of the drilling operation. In the LCB section, one core was taken through a sawed transverse pavement joint which was obviously "working". No crack was found in the LCB which is a further indication of lack of bond between the two layers.

COMPTON PROJECT
(February, 1975)

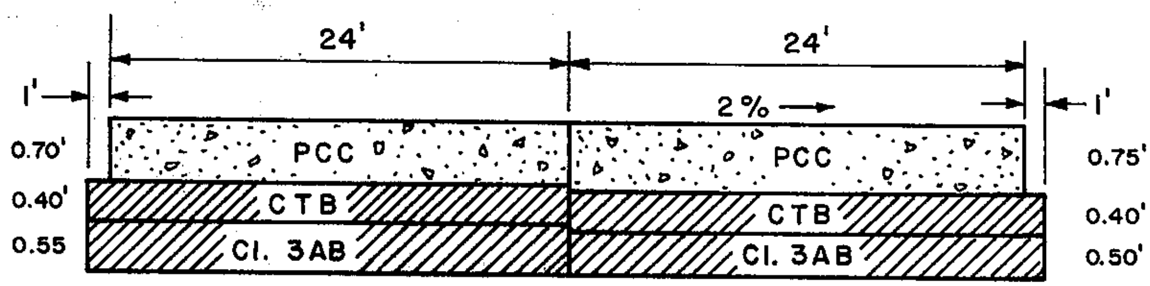
This project was located on State Highway 91 just south of Los Angeles. The Contractor, Kasler Constructors, proposed to construct about one half the base for the project with LCB. This amounted to approximately 10,000 cubic yards over some 3 miles of 4-lane highway. A contract change order, similar to the one at Monterey, was agreed on. Figure 3 shows the change in structural section made to accomodate placing the 50-foot base in one pass of the paver, simplifying construction. The stepdown at centerline is commonly specified to accomodate the change in pavement thickness of the outside lanes.

Aggregate samples were obtained for laboratory testing to determine cement content necessary for LCB. Aggregates for Class 3 aggregate base, CTB, and LCB were made from reclaimed roadway materials consisting of concrete pavement, CTB, asphalt concrete, curbs, drop inlets, and other miscellaneous waste, including clay, and stockpiled at the jobsite (see Figure 4). Recyclying of these roadway materials represents a significant savings in aggregate costs.

TYPICAL STRUCTURAL SECTIONS



LCB



CTB

Figure 3

Figure 4
Stockpile of Reclaimed Roadway Materials

Aggregate was produced at the jobsite in 3/4-inch maximum size for CTB, but in 1-1/2-inch maximum size for aggregate base and LCB. A typical grading of the latter was:

Standard Sieve	Percent Passing
1-1/2-inch	100
3/4-inch	82
3/8-inch	60
No. 4	42
No. 30	19
No. 200	8

Sand Equivalent - 48

Initial laboratory tests showed that something (probably in the aggregate) caused the entrainment of air in the plastic mixes - 8.5 percent air when using 5 percent cement, and 6 percent air when using 9 percent cement. The action was assumed to be caused by the asphalt or oils in the aggregate though no attempt was made to confirm this. Since the entrained air was considered excessive, Tributyl Phosphate (1/2-oz./sk. of cement) was added to detrain air. Air content was thus reduced to 3-4 percent.

Cement content for the LCB was set at 8 percent to provide a 7-day compressive strength of approximately 500 psi. Water needed to produce a slump of 2 inches was about 13 percent. Cement content for the CTB was 5 percent as specified in the special provisions for the project.

The Contractor's plans called for placing a portion of the CTB first, then switching to LCB. Laboratory personnel were present during a total of 6 days of base placement to monitor production and obtain samples of both types of bases.

For the first 3-1/2 days, CTB was placed. On this project, the Contractor elected to use the same plant and mixers as he would later use for LCB and pavement concrete (see Figure 5).

The CTB mixture was hauled to the grade in bottom dump trucks, each carrying about 16 cubic yards. Mix was deposited in front of a CMI Autograde which spread the material in 25-foot widths to approximate grade (see Figure 6). After initial compaction, the same machine would later back up and trim to a closer grade (see Figure 7). After recompaction, the surface was sprayed with an asphalt curing seal.

No problems were encountered in the placement or compaction of the CTB. Production was held up or slowed numerous times, however, due to the subgrade pumping and failure requiring repair. As seen in Figure 3, there was only about 6 inches of aggregate base over the embankment material. This latter material had considerable clay in it and was very critical as to optimum moisture content. Due to frequent rains before base placement, too much moisture had soaked into the embankment in some places.

When pumping areas were found, the soft material was removed and the resulting hole was filled with either aggregate base or CTB. If pumping occurred on the grade immediately in front of the placing machine, there was a delay while a backhoe removed the unstable material and repairs made. On one day, some slowdown resulted from the breakdown of a belt feeding aggregate to a hopper at the plant. In 3-1/2 days, CTB production was 45,834 square yards, or, theoretically, 6,111 cubic yards.

During the next 2-1/2 days, LCB was placed. The mixture was dumped in front of a Kasler modified Blaw-Knox slipform paver, distributed by a front end loader (see Figure 8), then vibrated

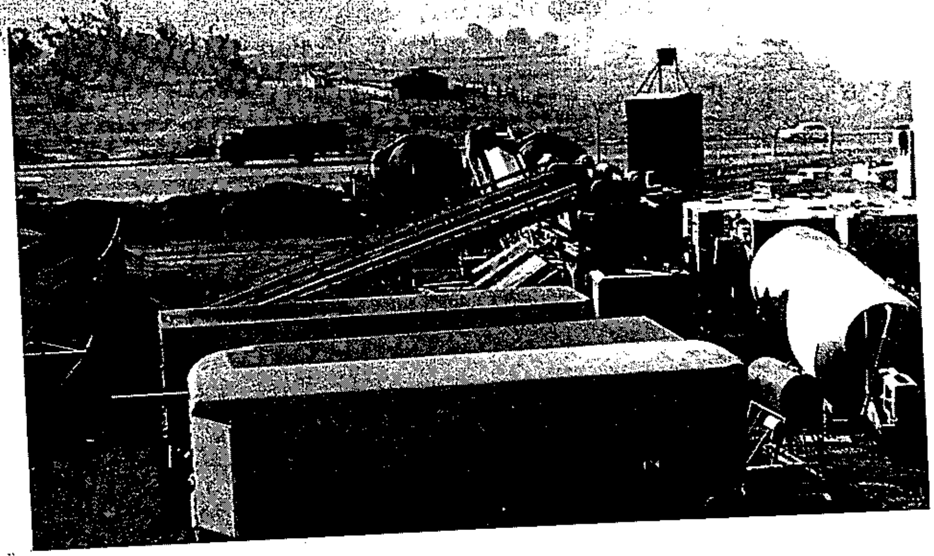


Figure 5
Batching Plant Used for Concrete, LCB and CTB

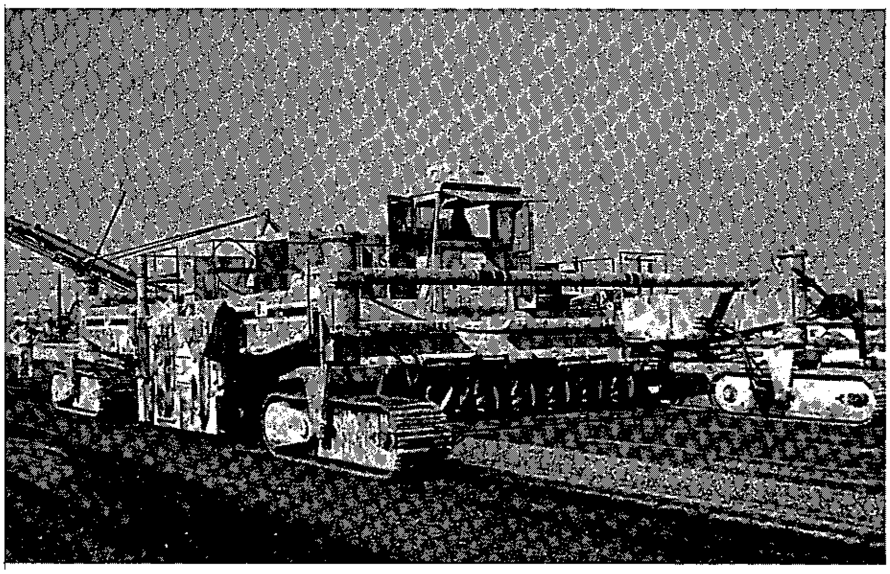


Figure 6
CTB Placing Operation

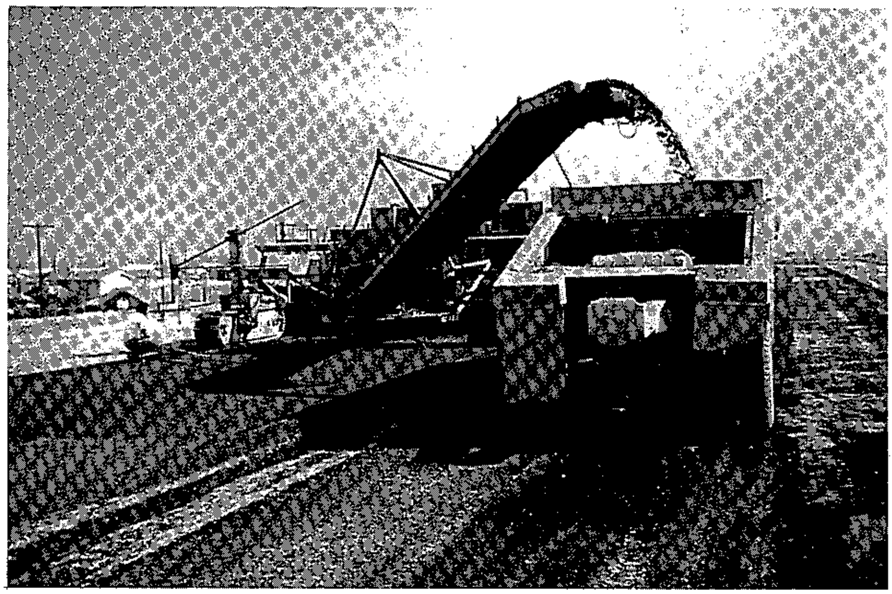


Figure 7
Trimming CTB

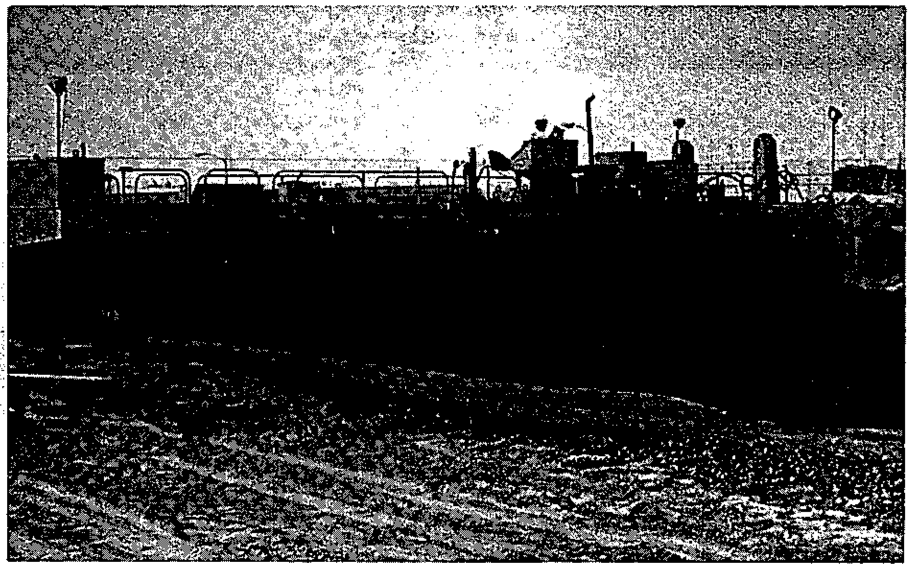


Figure 8
Distributing LCB in Front of Paver

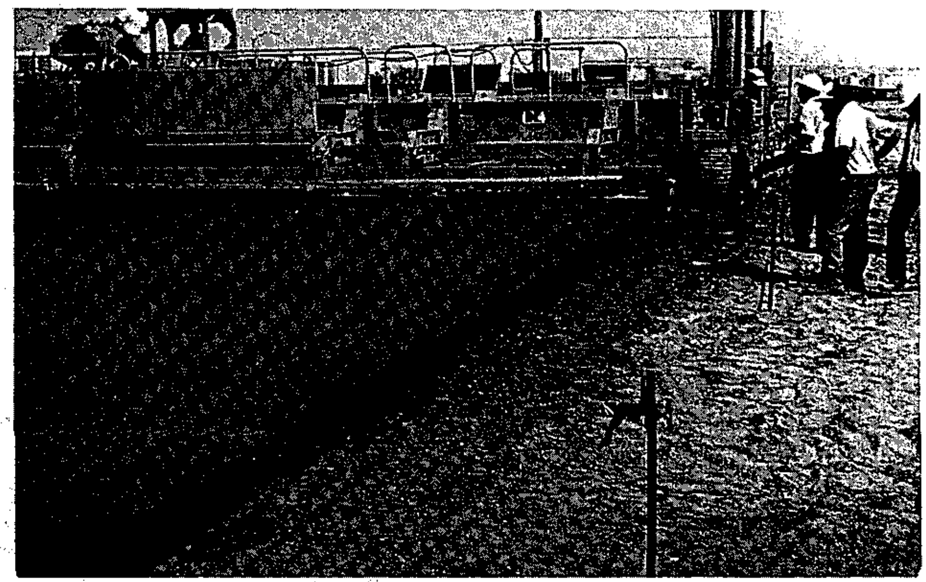


Figure 9
Finished LCB Surface

and struck off to grade by the paver for the full 50-foot width (see Figure 9). No further finishing was performed. The curing compound was sprayed on almost directly behind the paver. Placing of LCB was temporarily suspended after 2-1/2 days because of wet, soft subgrade. The remainder was placed about two weeks later.

The finished LCB slab had the appearance of a conventional PCC pavement slab except for lack of surface texture. Occasional minor irregularities from stoppages of the paving machine were left untouched. At two such locations small concentrations of excessively fine or clay-like material were detected. The source of the fines was probably from the raw material stockpile or native soil under the stockpile. It is assumed that the additional vibration from the paving machine at a stopped location tended to concentrate fines at the surface. Concern for this condition was minimal and overall structural integrity appeared to be unaffected.

Further observations concerning structural strength were made during paving. Loaded trucks had to use both the CTB and LCB as haul roads. At a few locations on the CTB, pumping started and extensive damage resulted requiring later removal and replacement. No cracking or other damage due to loading was found in the LCB. The closest intervals of transverse shrinkage cracking in the LCB were between 75 and 100 feet.

Just before pavement was placed, Benkelman beam deflection measurements were made on about 1000 feet of each type of base. Both sections were 19 days old. Deflections of the CTB ranged from .012 to .040-inch with an average of .024-inch. For the LCB, the range was .008 to .021-inch with an average of .012-inch. The greater stiffness of the LCB may provide a bridging action and account for the lack of damage from loaded trucks.

Four sets of samples were taken from each of the two types of base for compressive strength tests. Cores were taken after about three weeks for 28-day breaks (see Figure 10). Additional cores were taken at about 12 weeks for 91-day tests. Results are shown in Table 3. At LCB site 4, one of several excessively wet loads was deliberately sampled. The field fabricated specimens had very low strength, but evidently due to manipulation by the loader, the wet mixes did not end up at the sampling location since core strengths at 28 days at this location were the highest of all tested. The cores for 91 day tests, taken only a few feet away from the previous coring, did reflect lower strengths.

Fresh concrete tests were made by project personnel and were not from the same batches sampled for compressive strength tests. Generally, Kelly Ball Penetration was about 2 inches (approximately 4 inches slump and probably higher than necessary), and air content was between 3.5 and 4.5 percent. Tributyl phosphate was added at the rate of 1/2-oz. per 100 lbs. of cement to keep the air content down to this level. Moisture content was about 16 percent by dry weight of the aggregate.

Cores for abrasion tests were also taken at 28 and 91 days. Result of the impact type abrasion test are shown in Table 3. Due to the asphalt curing seal on the CTB, there was very little loss of surface during testing. During construction, the possibility of bond to pavement and the asphalt membrane affecting results had been considered. Twelve-foot squares of black polyethylene were nailed to the base at selected sampling locations. Unfortunately, each night after placement, the plastic was vandalized and the base at that point did not receive proper curing. No cores were taken at these areas. An attempt was also made to remove the asphalt curing seal before testing for abrasion; however, due to non-uniformity of density of the surface, the asphalt had penetrated

Figure 10
Cores of LCB (Left) and one of CTB (Right)

Table 3

Lean Concrete Base			COMPRESSIVE STRENGTH (PSI)						Abrasion Loss, (Gm)	
			6x6 Field Fab.			6x12	5" Core		4" Core	
Site	Station	Lane	7-day	28-day	91-day	28-day	28-day	91-day	28-day	91-day
1	368+75	WB 1	455) 470)465 465)	630) 605)605 575)	875) 920)900 900)	535) 525)530 525)	710) 640)675 670)	990) 900)930 900)	0.3) 2.9)1.2 0.4)	0.7) 1.0)0.9 0.9
2	378+70	WB 1	385) 400)390 390)	690) 685)675 655)	890) 930)915 925)	580) 590)585 580)	705) 685)695 695)	945) 935)915 865)	0.4) 0.2)0.3 0.3)	0.8) ---)0.6 0.3)
3	390+50	EB 1	410) 405)400 385)	550) 575)565 570)	760) 820)800 815)	510) 510)500 480)	665) 715)665 610)	715) 775)745 750)	3.9) ---)2.2 0.4)	
4	381+00	EB 1	150) 155)155 160)	245) 245)245 250)	385) 355)365 360)	170) 180)175 180)	765) 1060)905 885)	645) 610)615 590)	4.5) 4.3)3.6 1.9)	
Average			355	525	745	445	735	800	1.8	0.8

Cement Treated Base			COMPRESSIVE STRENGTH (PSI)					Abrasion Loss, (Gm)	
			4x4 Field Fab.			5" Cores		4" Core	
Site	Station	Lane	7-day	28-day	91-day	28-day	91-day	28-day	91-day
1	334+90	WB 1	910) 955)970 1050)	1105) 1210)1110 1020)	1610) 1465)1470 1335)	870) 700)775 750)	615) 790)705 705)	1.3) 2.3)2.5 3.9)	2.3) 1.0)1.5 1.2)
2	326+00	EB 1	1030 915)1035 1060)	1280 995)1115 1075)		645 505)555 510)	615 555)575 560)	5.4 1.7)3.6 ---)	
3	353+80	EB 1	965) 740)810 730)	1080) 930)1010 1010)		510) 530)515 510)	465) 475)500 555)	1.7) 1.2)1.7 2.1)	6.3) 6.5)4.9 2.0)
4	360+40	WB 1	990) 1000)970 920)	1075) 1170)1115 1105)	1330) 1290)1350 1425)	595) 570)605 645)	685) 815)830 985)	1.1) 1.5)1.3 ---)	
Average			940	1090	1410	610	650	2.2	3.2

Note: LCB specimens were compacted by rodding 25 strokes of 2 or 3 layers, and CTB specimens by tamping, then applying a 15,000 lb. load for 1 minute.

unevenly and left a surface unsuitable for testing. However, laboratory tests show that under moist cure conditions, LCB with about twice the cement of CTB is 400-500 percent more abrasion resistant than CTB.

As at Monterey, everyone who witnessed the LCB operation thought it was an excellent method of placing base. The general concensus was that the finished product was superior structurally to CTB and would definitely be more abrasion resistant. Production of LCB was also better - in 2-1/2 days, 53,001 square yards of LCB was placed, or theoretically, 7,067 cubic yards, compared to 45,834 square yards (6,111 cubic yards) of CTB placed in 3-1/2 days.

An attempt was made to make a cost comparison between the construction of CTB and LCB. The calculations of costs for the base placement are confounded by the delays encountered during production. It appears that only a portion of the additional cost of cement, etc., is offset by savings in equipment and higher production rates. Usually a Contractor brings in a separate plant for producing CTB. On this job the CTB was mixed in the concrete plant set up for the job. Therefore the costs involved in move-in and out plus set-up and dismantling of a CTB plant was not added to the CTB costs.

DISCUSSION

From laboratory and field tests, LCB appears to be equal or superior to CTB. The use of CTB was originally specified primarily to provide an abrasion resistant surface which would resist pumping, and compressive strength was a secondary consideration. Over the years, the presently used practices of placing CTB have evolved from a side form operation to a "formless" operation with trimming now being commonplace. The trimmed and re-rolled surface is not abrasion resistant. Compressive strength is usually the only property measured but does not necessarily relate to abrasion resistance.

The compressive strength tests indicate that even though the target strength of 500 psi for LCB was not reached in 7 days, sufficient strength was developed to withstand limited overloads in 3 days and numerous overloads after two weeks. It appears that 500 psi is a conservative value for base strength.

Less equipment is needed for placing LCB than CTB. A CTB plant need not be brought in and set up. No rollers are needed to provide compaction. The trimming operation is eliminated. Since compaction does not have to be checked, less inspection is required.

A possible disadvantage of LCB is slightly higher cost due to the extra cement necessary. With more experience, and perhaps some modification of the design it is believed that enough savings might be realized to offset all of the increased cement cost. Since LCB can be placed to a much closer tolerance than CTB, some consideration should be given to reducing base thickness requirements. Both Contractors reported considerably less overrun of concrete for pavement. This factor might help reduce bid prices on future jobs.

The two test sections will be monitored periodically to evaluate performance. The Monterey section has been opened to traffic for over two years and is performing well. There is very little heavy truck traffic using the highway, however, and significant findings on performance are not expected, at least for several more years. The Compton project will carry considerable heavy truck traffic and may provide performance information in a shorter time.

Following are features which should be included in specifications for LCB:

1. The cement content of LCB will be determined by the State, based on tests with aggregate selected for use on the project.

2. Cement gates at the batch plant shall be adjusted to provide uniform blending of aggregate and cement on the belt feed during charging of the mixers.

3. Minimum mixing time shall be 25 seconds after all ingredients are in the mixer. Additional time may be required if mixing is inadequate.

4. The Maximum Kelly Ball penetration of any LCB deposited on the grade shall be 2 inches (4" slump).

5. LCB shall be placed with approved concrete placing equipment and consolidated by internal vibration.

6. Longitudinal weakened plane joints shall be formed in the LCB at a location one foot offset laterally from each interior traffic lane line in multilane monolithic placement.

7. The finished surface shall have a uniformly closed texture. After strikeoff, no additional finishing effort will be required except that needed to maintain grade alignment. Areas higher than 0.05-foot above established grade shall either be removed and replaced with LCB to the required grade, or ground to proper grade by approved concrete grinding equipment. Low areas may either be removed and replaced or filled in with paving concrete.

8. LCB shall be cured by the pigmented curing compound method.

9. No traffic or Contractor's equipment will be permitted on LCB before a period of 72 hours has elapsed after placement. After 72 hours, trucks hauling paving concrete will be permitted to maneuver on the base for the minimum length necessary to get into position in front of the spreading equipment to deposit their loads.

10. After 7 days of cure, trucks with axle loads not exceeding 20,000 pounds per axle may travel on the LCB. Such overloads shall be limited to one lane in each direction, immediately adjacent to the median. Should block cracking or other distress occur, the Engineer may reduce such axle loads or prohibit further use.

REFERENCES

1. Spellman, D. L., et al, "California Pavement Faulting Study," California Division of Highways, Materials and Research Report, January 1970.

2. Spellman, D. L., et al, "Faulting of Portland Cement Concrete Pavements," Presented at the 51st Annual Meeting of the Highway Research Board, January 1972.